BACK-TO-SCHOOL SECTION – DIGITAL TROUBLESHOOTING

$1.25 ■ NOV 1978

# Radio-Electronics®

THE MAGAZINE FOR NEW IDEAS IN ELECTRONICS

## DIGITAL WIPER DELAY

Build it and add it to your car. Provides intermittent windshield wiper operation and is programmed automatically. Turn to page 60.

## AUDIO BREAKTHROUGH

New metal-particle tape for recording promises ultra-performance in the near future. For the complete story, turn to page 49.

## VIDEO TANK GAME

Use your cannon to destroy your opponent first but watch out for the barriers. Construction starts on page 52.

## CAPACITANCE METER

Part 2: 4-digit display reads out between 1 pF and 9999 μF. Turn to page 67.

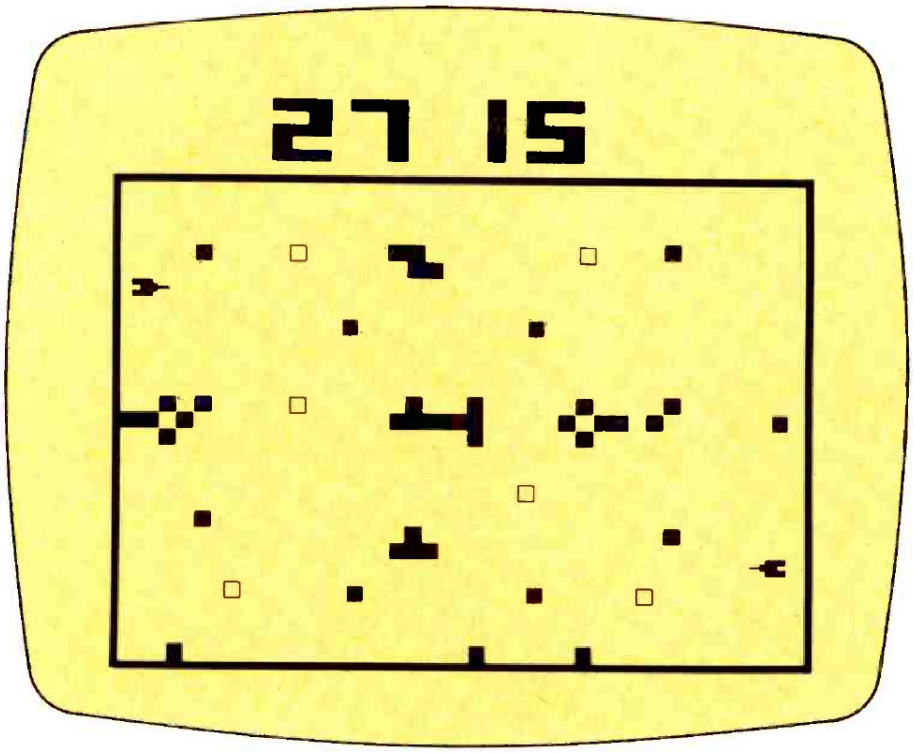
## COVER STORY
## UNUSUAL TELEPHONE

Built into a stylish handset is a complete telephone and amplifier. To see how it's done, turn to page 37.

## PLUS

- ★ Digital Crib Sheets
- ★ Computer Corner
- ★ Hobby Corner
- ★ Service Clinic

0 70989 34140 11




# TANK

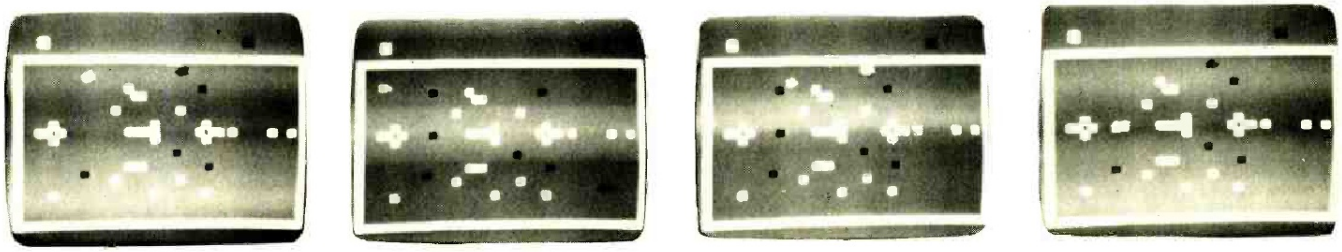
## arcade quality TV game

***Part 1. The object is to use your cannon to destroy your opponent first, but watch out for the land mines and anti-tank barriers. The circuit provides a composite video signal to your TV set and produces realistic sound effects.***

L. STEVEN CHEAIRS

A FEW YEARS AGO I WAS AFFILIATED WITH a small repair company that specialized in video games. After the arcade pong-type games were retired from the market, they were replaced by road race and tank games. At that time, a pong game filled a 10-inch by 14-inch printed circuit board, with about 80 to 100 TTL, SSI and MSI IC's. The road race, baseball and tank games used two or three cards of that size and composition.

In the last few years, the arcade units have been improved by using newer LSI IC's; and the older pong games are now produced on a single LSI IC for home use, with a television set used as a display. It is interesting to note that many of the first arcade games used a converted black-and-white TV set as a monitor. In fact, the prototype of the game described in this article was tested on a TV set that was removed from a retired arcade pong game. Although the monolithic game IC's have permitted these games to be played at home, the quality has always been inferior to the arcade games. Now with the newer LSI IC's, the quality of the games has improved dramatically.



The leader in home monolithic game IC's is General Instruments Corporation's Microelectronics Group. This company is now producing an arcade-level single IC tank game. This single IC, the AY-3-8710-1, replaces the set of PC boards traditionally used in the arcade-type game that contained a couple of hundred TTL logic circuits and read-only memories (ROM's). This undoubtedly represents the start of a new generation of dedicated home video games.

To start the two-player tank game, you simply press the reset pushbutton. Two tanks, one white and one black, suddenly materialize in a battlefield of antitank barriers and mines. Realistic engine sounds, provided for each tank, help create the illusion of combat; four distinct sounds are produced, one for each of the motor speeds and one for the stationary condition. Next comes the sound of gunfire, coupled with shell bursts and tank explosions—the illusion of battle is complete.

### Playing the game

The game was designed to work into a standard domestic 525-line black-and-white receiver.

When the game is reset, the scores are cleared (to 0), all the mines reappear and the tanks are placed in their corners. The tanks remain in a stationary state until the control sticks are manipulated. These control sticks are single-pole double-throw (SPDT) center-off, momentary-contact-type switches. When the player pulls the control sticks toward himself the tank advances at a slow speed. If the control sticks are held back for another ½ second, then the speed increases to medium. If the sticks are again held for another ½ second, the tank switches to high speed. When the sticks are released, the tank remains at the selected speed.

If the control sticks are now momentarily pushed in the opposite direction, the tank will stop. When the sticks are pushed forward, the tank backs up. Again, the speed increases for each ½ second the switches are closed, for a total of three speeds.

The tanks can be rotated by pushing one control stick forward and the other back. Rotation in the opposite direction occurs when the control sticks are reversed. Rotation may occur during all seven motion states—stationary, three speeds forward and three speeds backward. Rotation stops when the controls are returned to the normal standby position. A total of 32 rotation angles are provided.

The main gun is fired by pressing the SPST normally open pushbutton switch. A shell exits from the gun barrel and traverses the screen, unless it hits the enemy's tank or a barrier. The gun's range, if it is fired along the horizontal axis is about two-thirds of the TV screen; the range for the other directions varies with the angle. The switch must be depressed for each firing; only one shot every four seconds is possible. The shell explodes when it hits an object or reaches the end of its range. If a shot is fired during a tank rotation, the shell follows a curved trajectory—in the direction of the tank rotation.

Twenty-two fixed-terrain antitank barriers are provided. These barriers can retard or help your progress in the game. They stop shells and tanks if the BARRIER INTERACTION switch is closed—for the AY-3-8710-1 IC only. This switch is not included in the prototype model designed around the AY-3-8700-1. Also, six mines are distributed over the battlefield area. When a tank hits one of these mines—the tank explodes and fragments momentarially, as it does when hit by a shell. When the tank image returns, it is stationary and the gun is inactive for about 2 to 4 seconds. The mine that was hit vanishes for the rest of the game. If you hit a mine a point is scored for the enemy's tank.

Scoring is automatic. When a tank is hit by gunfire or it hits a mine, this increments the opponent's score. The game ends when a player's score indicates a total of 16 points; the score then flashes at a 1-Hz rate and no further points are recorded. Of course, the object of the game is to maximize your score while minimizing your opponent's score.

The audio output is provided on five lines—one for each tank motor (plus bearing and track squeak), a gunfire envelope, an explosion envelope and a noise source. Figure 1 shows a typical waveform observed on the prototype tank game. In a typical system the tank motor sounds are summed. The noise and gunfire envelopes are gated with the noise output. These signals are summed with the motor noise. The composite audio signal then drives an audio-output amplifier that drives the speakers.

### The circuit

The circuit described in this article is a modification of one shown in *Application Note Bulletin 104* developed by M. S. Sellars III, senior design engineer, Gen-

## PARTS LIST

**All resistors are ¼ watt, 5%.**
R1—180 ohms
R2—510 ohms
R3—470 ohms
R4—1800 ohms
R5—1000 ohms
R6—270 ohms
R7, R16, R19, R20, R23, R28—10,000 ohms
R8—1600 ohms
R9—2400 ohms
R10—12 megohms
R11—220 ohms
R12—5000-ohm, PC-type potentiometer
R13—2.2 megohms
R14—2200 ohms
R15, R21, R26—20 megohms
R17, R22—3.9 megohms
R18—22,000 ohms
R24, R25—10 megohms
R27—30,000 ohms
R29—15 ohms
C1, C2—100μF, 50-volt electrolytic
C3—2.7-μF tantalum
C4—C6, C13, C14—0.1-μF disc
C7, C8—30-pF disc
C9, C10—0.01-μF disc
C11, C12—0.22μF
C15, C16, C20—5 μF
C17—0.47 μF
C18—200 pF disc
C19—100-pF disc
C21—220-μF, 15-volt electrolytic
D1-D10—1N4148 or similar
D11-D14—1N4005 or similar
Q1—Q3—2N3904 or similar
IC1—AY-3-8700-1 or AY-3-8710-1 LSI game
IC2, IC3—4001, CMOS quad NOR gates
IC4—78M05, 5-volt regulator
J1—miniature open-circuit jack
S1—S4—SPDT center-off, momentary-contact toggle switches
S5—S7—SPST normally open pushbutton switch
S8—SPST switch
S9—SPST toggle switch
T1—12VAC, 1A secondary transformer
XTAL—4.090900-MHz crystal
SPKR—8 ohms
MISC.—12 × 7 × 3-inch aluminum chassis, line cord, hook-up wire, four 1½ inch stand-off busings.

**The following parts are available from Questar Engineering Company, McDonald Street, Mesa, AZ 85202: PC board, $12.95; AY-3-8700-1 or AY-3-8710-1 (please specify), $29.00; crystal, $5.50; set of all switches, $12.25. Kit of all parts, $63.95.**

eral Instruments Corporation, Microelectronics Group.

Figure 2 shows a block diagram of the tank game system and Fig. 3 is the schematic diagram. Block one is the game IC, which, it is claimed, is more complex than most microprocessors. There are also two IC's, the AY-3-8700-1 and AY-8710-1. The two circuits are identical with the exception of one input pin: The AY-3-8710-1 has a barrier interaction select input, pin 22. If the pin is left floating, the two IC's function identically. On the other hand, if the input pin is brought to the system ground potential, then the tanks cannot drive over the barricades.

Block two in Fig. 2 is a crystal-controlled clock. One inverter is used along with two resistors, two capacitors and a crystal to form a 4.0909-MHz oscil-

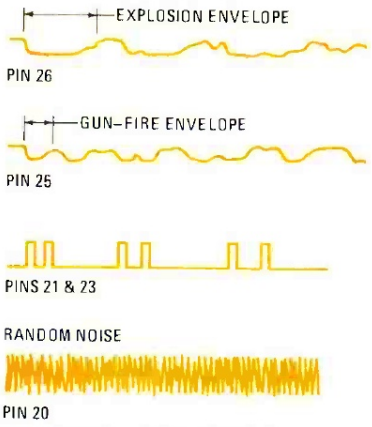



**FIG. 1—TYPICAL AUDIO SIGNALS as they appear at the pins of the pins of the game IC.**

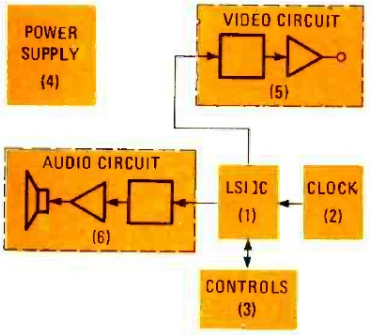
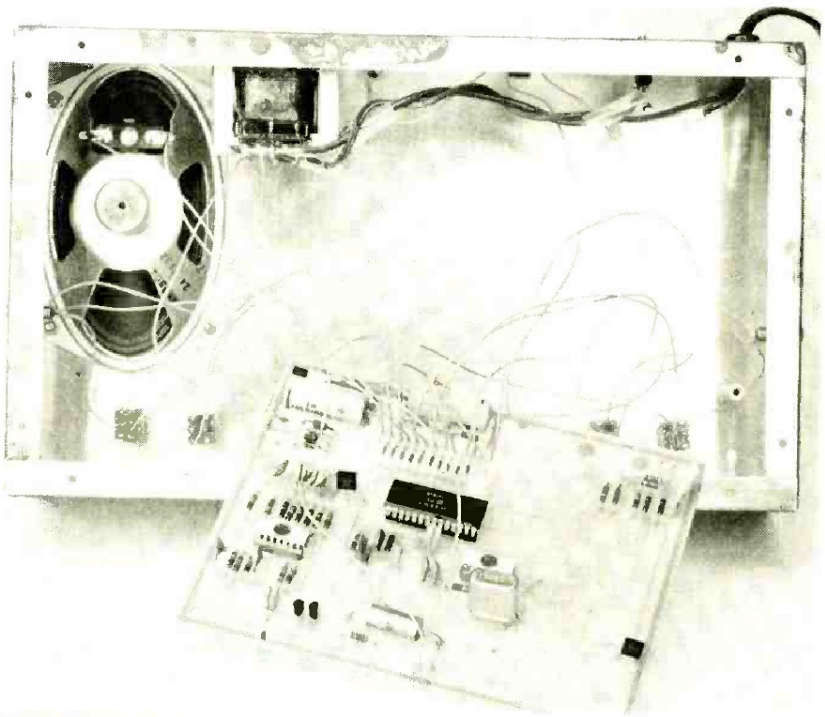



**FIG. 2—BLOCK DIAGRAM of the tank battle game. Sections 5 and 6 are included on the LSI game integrated circuit.**



**UNDER-SIDE VIEW of the tank game's chassis/enclosure. All components except the speaker, power transformer and switches are mounted on the printed-circuit board.**

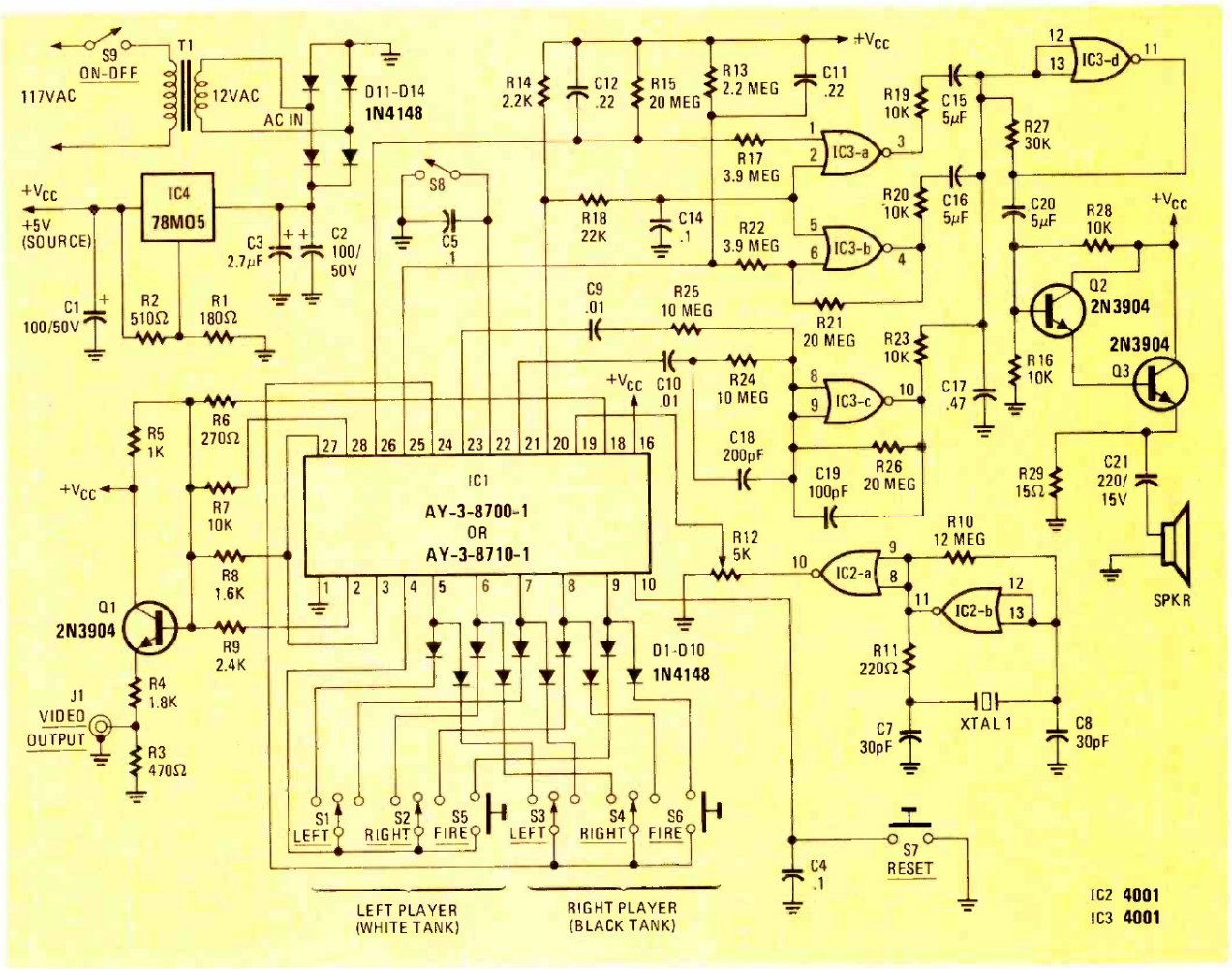



**FIG 3—SCHEMATIC DIAGRAM of the tank battle video game. When using the AY-3-8700-1 IC, do not connect anything to pin 22.**

lator. The output is isolated by passing the signal through another CMOS inverter. This inverter drives a 5,000-ohm potentiometer. This pot is adjusted so that the signal amplitude provided by this pot is between a 3.0-volt to 3.2-volt peak level.

The third block represents the controls. Eight switches, ten diodes and two capacitors are required. The four SPDT center-off momentary-contact switches are used to control the tank motions; the two SPST normally open pushbutton switches are used to fire the tank's main gun. The diodes provide isolation between these switches, thus allowing multiple closures. Reset is provided by an SPST normally open pushbutton and an 0.1-μF capacitor; the capacitor provides for a small amount of debouncing. The last switch, an SPST-type, and its capacitor select the barrier interaction.

Block four, the power supply, takes a 12-volt AC input and generates a 7-volt regulated DC output. Four 1-amp rectifiers convert the AC voltage into a pulsating full-wave DC voltage. Next, a filter capacitor smooths the ripple. The regulator is a 5-volt three-terminal unit. Two volts are dropped across the ground resistor. Another filter capacitor is used on the output.

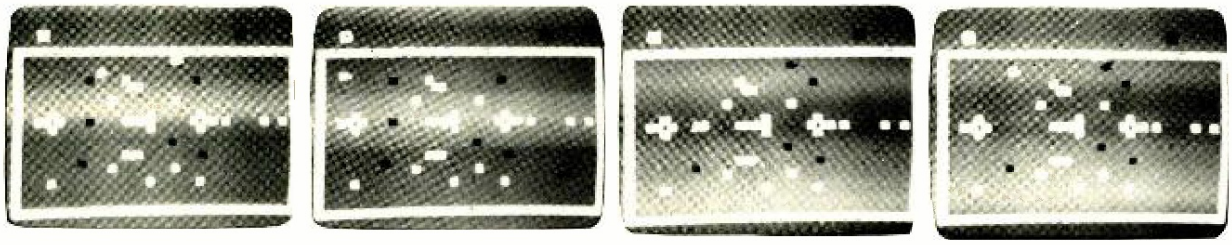
Block five represents the video-summing and video-amplifier circuits. The passive summing circuit sets the luminance level (by the ratios of the resistors). Five outputs are provided: Sync; right tank/score/shells/shell burst/mines; left tank/score/shells/shell burst/mines; background; and blanking.

One tank is white, the other is black and the background is gray. The black video outputs and blanking are tied to a single resistor since the modulation levels are approximately equal. The video amplifier is formed using one NPN 2N3904 transistor and an emitter voltage divider. In Mr. Sellars' *Application Note*, this amplifier drove an Astec UM1082 RF modulator. If a different modulator is used, then the summing resistors and the emitter resistor may have to be adjusted. In the prototype version, the video signal was fed directly into the TV set's video amplifier; thus, no modulator was used.

Block 6 is the audio-output network. The speaker is driven by the emitter of a Darlington transistor amplifier via a DC blocking capacitor.

*continued next month*

BUILD THIS



# TANK

## arcade quality TV game

***Part 2. The object is to use your cannon to destroy your opponent first, but watch out for the land mines and anti-tank barriers. The circuit provides a composite video signal to your TV set and produces realistic sound***

L. STEVEN CHEAIRS

LAST MONTH, WE PROVIDED THE COMplete schematic of the tank game and discussed in detail the circuit operation.

This month, the article concludes with the foil pattern, component placement diagram and construction details.

### Building the game

Before beginning construction, you will need an etched and drilled PC board. You can use the foil pattern in Fig. 4 or purchase the board from the source listed in the parts list. Begin by installing the five jumpers on the drilled board (Fig. 5) and then solder all resistors, capacitors and IC sockets to the board. Next, solder in the diodes, transistors and the regulator IC.

Before proceeding, connect a 12-VAC transformer to the AC input; connect a DC voltmeter across the power-supply pins of the game IC; pin 1 is ground and pin 16 is $+V_{cc}$. Now, apply line power to the transformer—7 volts should be indicated on the meter. If 7 volts is not shown but some value close to it, then a new value for R1 or R2 can be chosen by trial-and-error. If the voltage is drastically different, then a circuit problem exists; use normal troubleshooting techniques to locate and repair the problem.

Next, install the CMOS IC's. Again apply power; using an oscilloscope, adjust the amplitude of the clock at pin 19 of the LSI IC. Remove the power source and discharge the capacitor. Install the AY-3-8700-1 or AY-3-8710-1 IC; the circuit board is now complete. Wire the external components to the PC board (see Fig. 6) and install the unit into a case. If an RF modulator is used, it can be mounted in the case with the PC board or inside the TV set. One last note, the best results were obtained from the prototype with the TV set's contrast control turned up and the brightness control turned to medium-low.

### Special considerations

There are several considerations that should be noted for the AY-3-8700-1. First, as the tanks rotate, the shape of their images will vary. Next, the border width will vary from integrated circuit to integrated circuit. Also, the mines could disappear upon interaction with the tanks. When a score is recorded the black tank rotates and the white does not. The 4-second delay makes this effect immaterial. If the tanks exit the screen area, sometimes they will disappear and never return.

For the AY-3-8710-1, the following considerations are important. Upon resetting of the game a random explosion may occur (it may be visible below the bottom border). Also, during the game the gun of either tank may misfire; that is, shells may explode in a spot where the player is not aiming or the shell may not fire from the tank. These do not affect the normal events of the game.

It is possible for a tank to get trapped in a border. When this happens, the game is ended and the other tank is declared the winner. If the barrier interaction switch is

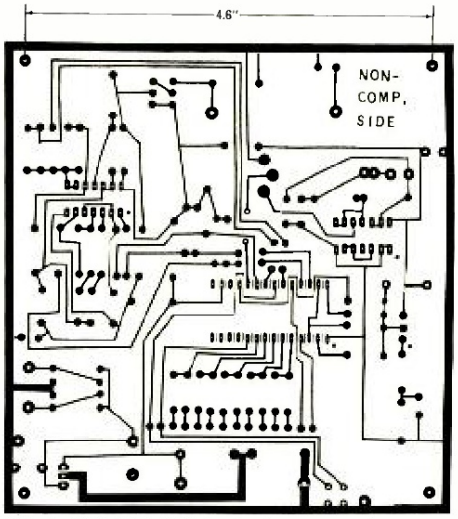



**FIG. 4—FOIL PATTERN for the battle game PC board.**

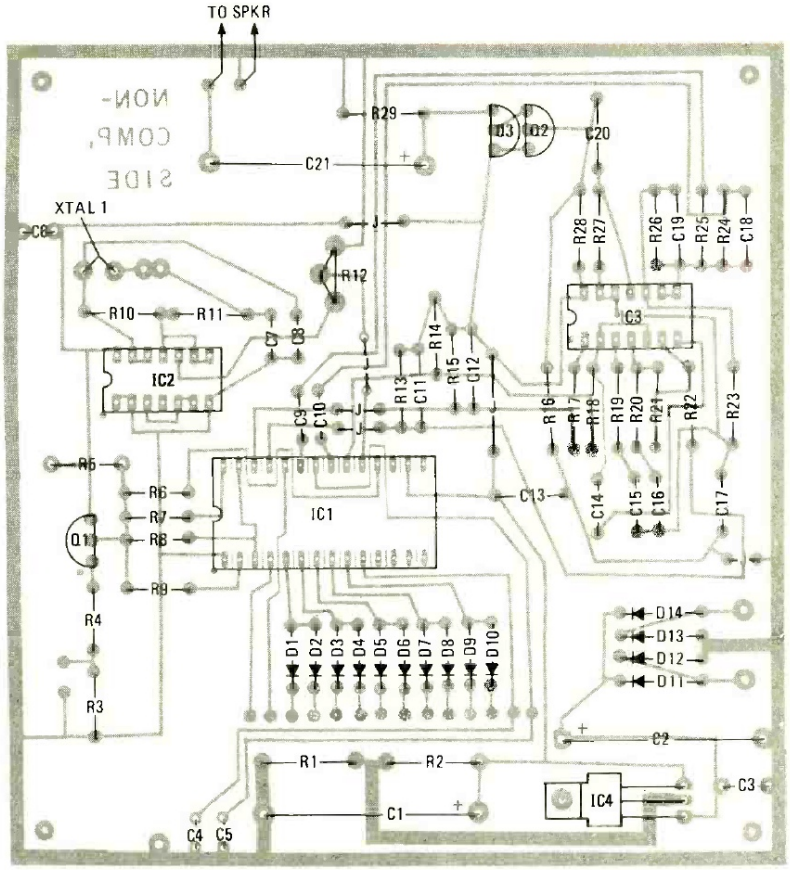



**FIG. 5—COMPONENT LAYOUT showing positions of all on-board parts. Switches, speaker and power transformer are mounted in the case.**

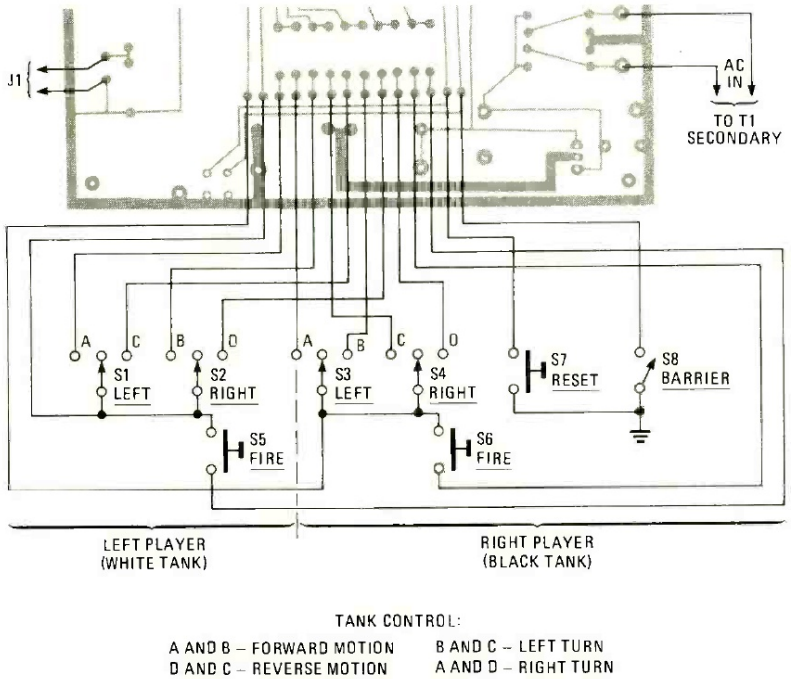



**FIG. 6—HOW SWITCHES ARE CONNECTED to the game IC on the board. Lower section of the component side of board is shown for reference.**

## PARTS LIST

**All resistors are ¼ watt, 5%.**

R1—180 ohms
R2—510 ohms
R3—470 ohms
R4—1800 ohms
R5—1000 ohms
R6—270 ohms
R7, R16, R19, R20, R23, R28—10,000 ohms
R8—1600 ohms
R9—2400 ohms
R10—12 megohms
R11—220 ohms
R12—5000-ohm, PC-type potentiometer
R13—2.2 megohms
R14—2200 ohms
R15, R21, R26—20 megohms
R17, R22—3.9 megohms
R18—22,000 ohms
R24, R25—10 megohms
R27—30,000 ohms
R29—15 ohms
C1, C2—100μF, 50-volt electrolytic
C3—2.7-μF tantalum
C4-C6, C13, C14—0.1-μF disc
C7, C8—30-pF disc
C9, C10—0.01-μF disc
C11, C12—0.22 μF
C15, C16, C20—5 μF
C17—0.47 μF
C18—200 pF disc
C19—100-pF disc
C21—220-μF, 15-volt electrolytic
D1-D10—1N4148 or similar
D11-D14—1N4005 or similar
Q1-Q3—2N3904 or similar
IC1—AY-3-8700-1 or AY-3-8710-1 LSI game
IC2, IC3—4001, CMOS quad NOR gates
IC4—78M05, 5-volt regulator
J1—miniature open-circuit jack
S1-S4—SPDT center-off, momentary-contact toggle switches
S5-S7—SPST normally open pushbutton switch
S8—SPST switch
S9—SPST toggle switch
T1—12VAC, 1A secondary transformer
XTAL—4.090900-MHz crystal
SPKR—8 ohms
MISC.—12 × 7 × 3-inch aluminum chassis, line cord, hook-up wire, four 1½-inch stand-off busings.

**The following parts are available from Questar Engineering Company, McDonald Street, Mesa, AZ 85202:**

**PC board, $12.95; AY-3-8700-1 or AY-3-8710-1 (please specify), $29.00; crystal, $5.50; set of all switches, $12.25. Kit of all parts, $63.95.**

selected, the tank cannot drive through barriers. If a tank gets trapped in a barrier, momentarily flip the barrier interaction switch to allow the tank to free itself. Also, sometimes the tanks may get locked together; the only way to separate them is to reset the game. In playing both the AY-3-8700-1 and AY-8710-1 games I very seldom have problems of the type outlined above. These special considerations are presented so that you know what to do in case a problem is encountered. **R-E**